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(54) Abstract Title
Blasting metallic surfaces

(57) A metallic surface 7 is blasted with abrasive particles 5 comprising a metallic nitride and/or silicon nitride. The abrasive particles 5 preferably have an average fracture toughness of 5-5-10.0 Mpa*m$^{1/2}$. The abrasive particles 5 are preferably selected from aluminium nitride, titanium nitride, sintered silicon nitride or hot pressed silicon nitride and have an average diameter between 150-600 μm. The method may be used to blast the surface of a layer 3 of an MCrAlY alloy which has been bonded to a workpiece 2 such as a turbine component. A ceramic thermal barrier layer (4, fig. 3, e.g. zirconia or a metal ceramic oxide) is then bonded to the blasted MCrAlY layer 3. The surface of the workpiece 2 may also have been blasted with abrasive particles 5 comprising a metallic nitride and/or silicon nitride (fig. 1).

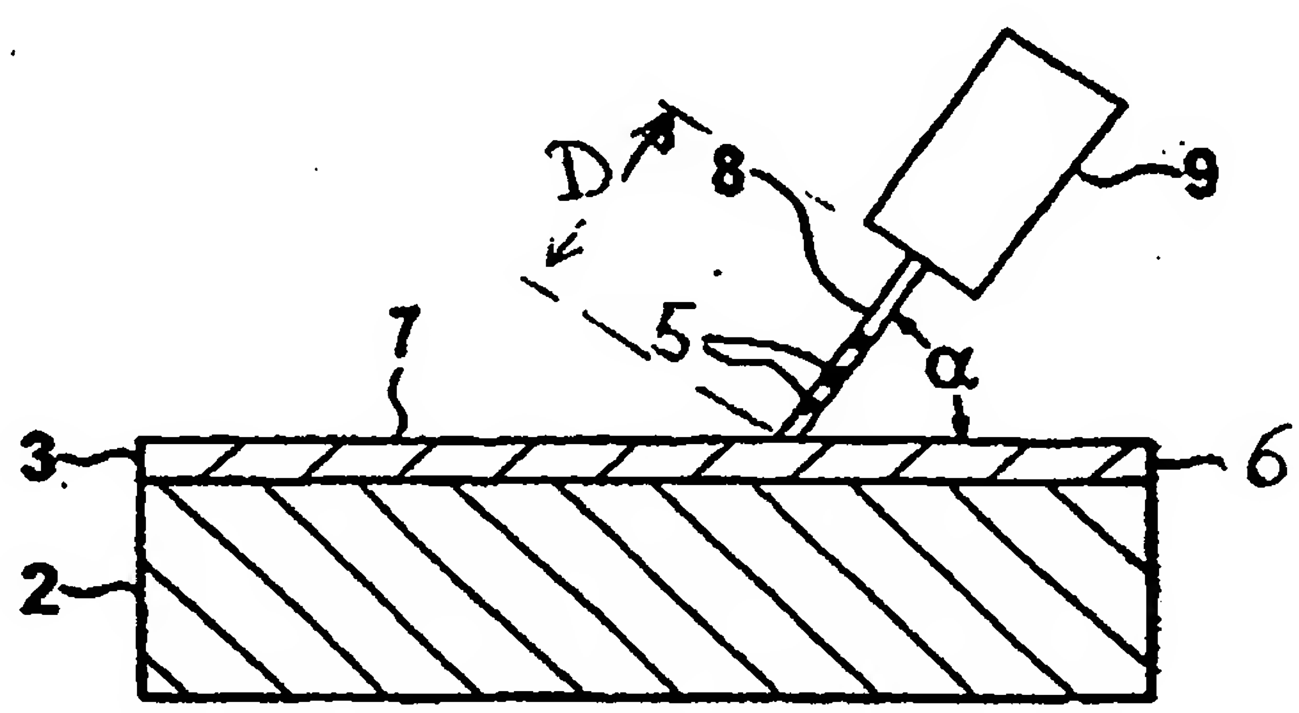

FIG 2

GB 2 375 725 A

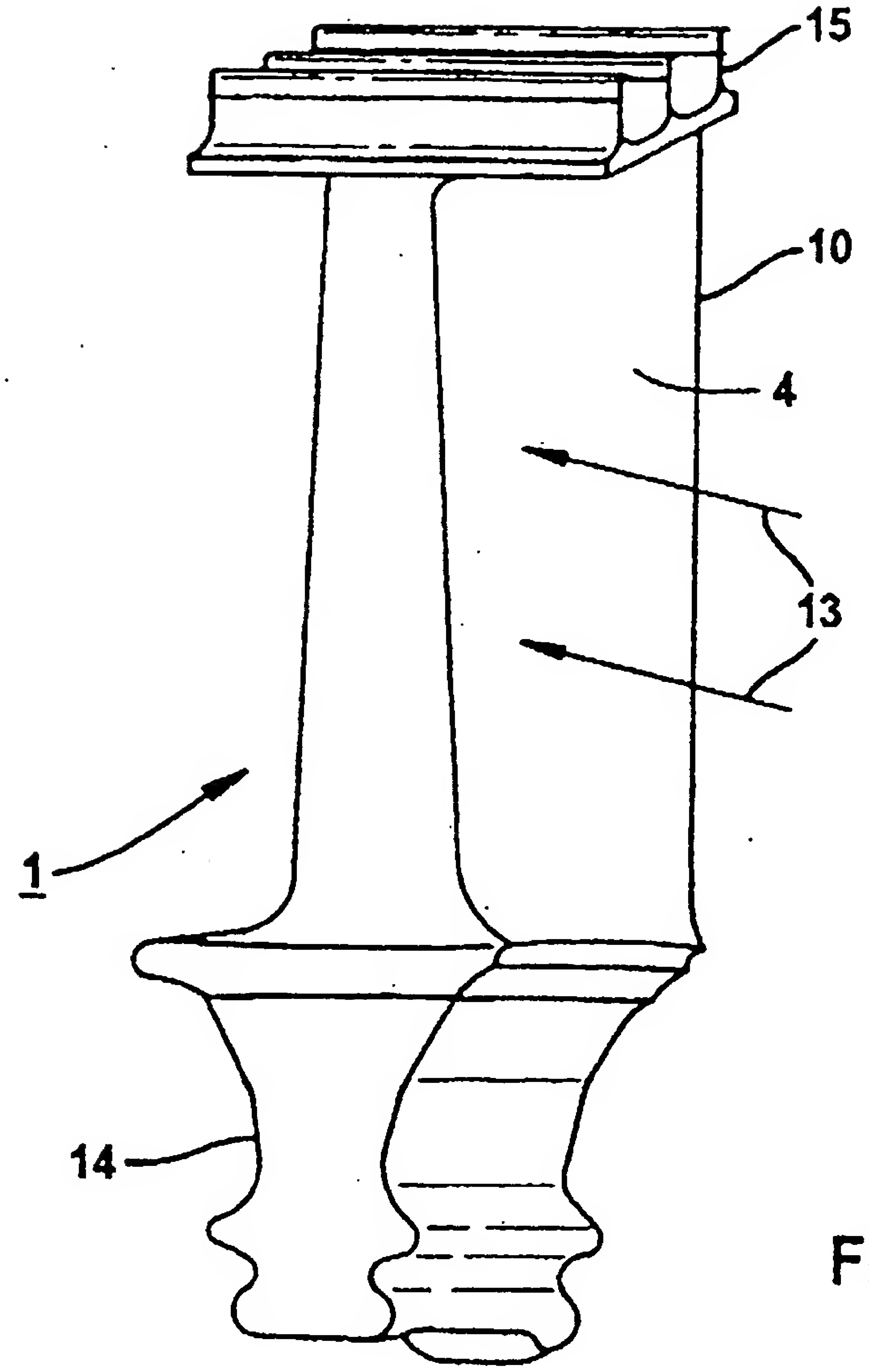

FIG 4

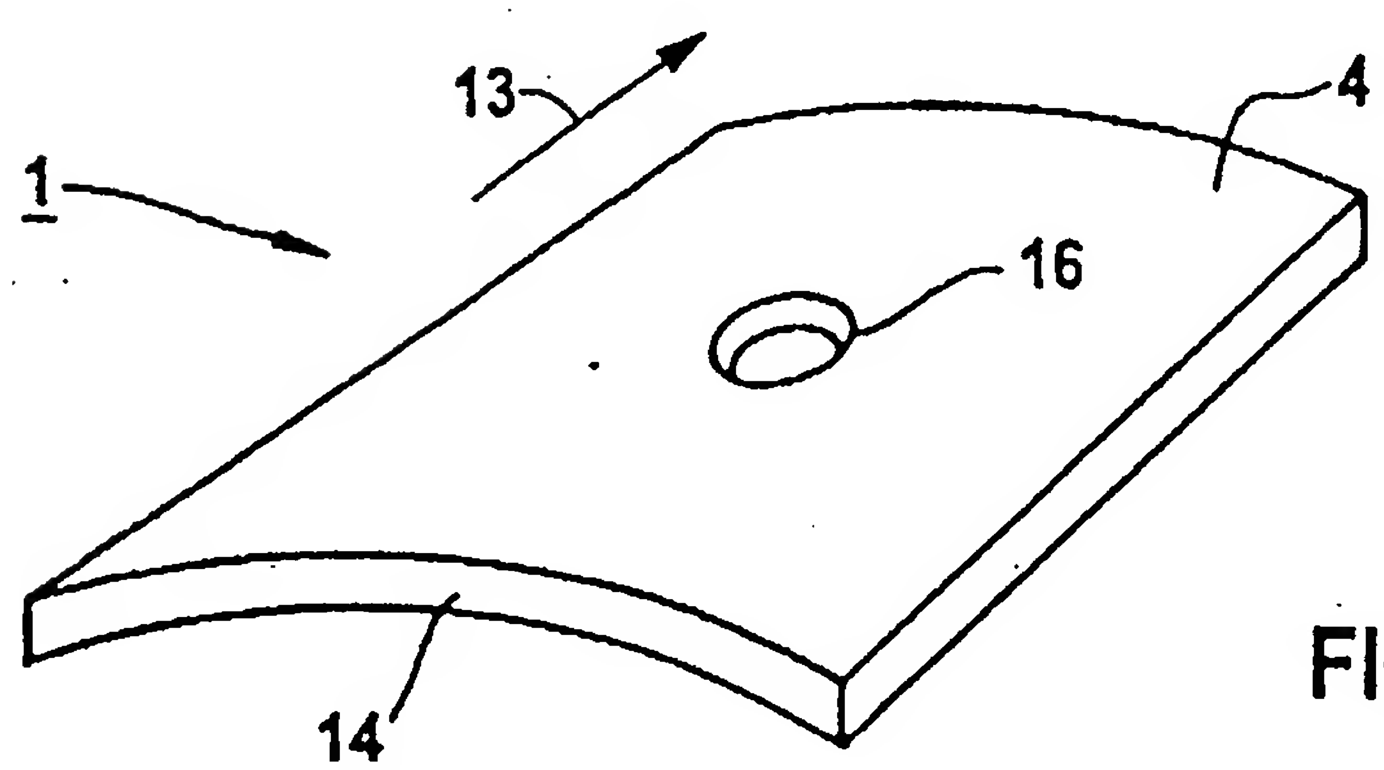

FIG 5

METHOD FOR A MECHANICAL TREATMENT OF A METALLIC SURFACE

TECHNICAL FIELD

The invention relates to a method for a mechanical treatment of a surface of a metallic substrate of an article of manufacture, in particular for an article of manufacture to be exposed to a hot temperature and to be coated with a protective coating, wherein the surface is treated with abrasive particles.

BACKGROUND OF THE INVENTION

In US-Patent 5,993,980 to Schmitz et al. a protective coating for protecting a component, in particular a gas turbine blade, from corrosion and oxidation at a high temperature and from excessive thermal stress is disclosed. This coating has a heat insulation layer including a ceramic material and an adhesion-promoting layer including a rhenium containing metal alloy. The metal alloy belongs to the alloys covered by the general term MCrAlY, where M represents cobalt and/or nickel and Y represents yttrium and/or at least one equivalent metal from the group including scandium and the rare earth elements. After binding the adhesion-promoting layer to the base material of the gas turbine blade by interdiffusion, smoothing of the adhesion-promoting layer to a maximum roughness of 2 μm is carried out by vibratory grinding, before which, if required, blasting can be effected using glass beads or sand.

In US- Patent 5,683,825 to Bruce at al. a thermal barrier coating is described in which a bond layer is polished to have an average surface roughness R_a of at most about two micrometers, as measured in accordance with standardised measurement procedures, with a preferred surface roughness being at most about one micrometer R_a with out indicating which method may be used to achieve such a surface roughness.

In EP 1 016 735 A1 a method for coating a component of a gas turbine is described. On this component an adhesion metallic layer is bound, whereby on this adhesion

layer a ceramic thermal barrier layer is bonded. Prior to applying the thermal barrier layer the metallic layer is grit blasted with abrasive materials consisting of the same material as the ceramic thermal barrier layer, wherein the ceramic thermal barrier layer consists of zirconia.

In EP 0 814 178 A1 and EP 0 845 547 A1 a multi-layer thermal barrier coating for a superalloy article is described. This comprises a platinum enriched superalloy layer, an MCrAlY bond coating on the platinum enriched superalloy layer, a platinum enriched MCrAlY layer on the MCrAlY bond coating, a platinum aluminide coating on the platinum enriched MCrAlY layer, an oxide layer on the platinum aluminide coating and a ceramic thermal barrier coating on the oxide layer. After a heat treatment the surface of the bond coating is grit blasted with dry alumina powder to remove any diffusion residues. The ceramic thermal barrier coating is then applied by EBPVD, to produce a thin oxide layer on the platinum aluminide coating with a platinum enriched gamma phase layer there between.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an efficient method for a treatment of a metallic surface, in particular suitable for preparing the surface prior to applying a coating, in particular a ceramic coating.

With the forgoing and other objects in view there is provided, in accordance with the invention a method for a mechanical treatment of a surface of a metallic substrate of an article of manufacture comprising the step of treating the surface with abrasive particles, which particles comprise a metallic nitride and/or a silicon nitride.

A method for treating the surface of a metallic substrate is provided, which assures a predefined surface roughness and an activation of the surface. The surface treated in this manner achieves a good bonding of layers deposited on the substrate by for example conventional spraying methods. The layers may equally be ceramic layers or metallic layers, in particular metallic adhesion layers.

Known methods use for example particles consisting of aluminium (Al_2O_3), which is quite inexpensive, or silicon carbide (SiC) and lead to a smoothing and roughening of a surface of a substrate. The resulting surface structure is influenced to some extent by the pressure and the duration during which the particles hit the surface. According to the relative high brittleness of alumina such particles (blasting grains) often break in parts when hitting the surface of the substrate. In a method of using alumina as material for the blasting particles a substantial contamination of the substrate with broken particles remaining on the surface or being enclosed in the surface is to be observed. Mechanical treatment of the surface using aluminium may therefor lead to a contamination of the surface between 5 and up to over 10%. It has been observed that such a contamination of the surface leads to defective areas along the boundary between substrate and coating layer. Such defects along the boundary may lead to a defective article of manufacture with respect to its coating so that this article of manufacture is of no use and hence has to be immediately refurbished or an early failure of the article manufacture would occur, when using it. In particular when the articles of manufacture are exposed to a high temperature - for example in a combustion turbine or even more particular for articles of manufacture which are moving parts - such an early failure is not acceptable. Furthermore it has been found that by using alumina (corundum) it is necessary for obtaining a predetermined roughness of the surface a relative low blasting pressure has to be applied due the high brittleness of alumina. Due to the high probability of fracture rather small grains are used instead of larger ones. So using a relatively low blasting pressure and small grains the roughness which could be obtained is less than by using more coarse-grained particles. This results in a longer duration for the blasting process which than again leads to a higher contamination rate which affords a further cleaning of the surface - for example using ultrasonic method - and a further washing step.

Using metallic nitride an/or silicon containing nitrides according to the invention having a higher fracture toughness of the particles leads to a lower brittleness and therefor less particles break in parts when hitting the surface. By adjusting the process of mechanical treatment with respect to blasting pressure, the size of grains, the material chosen for the grains a contamination of the substrate can be reduced and so further steps of cleaning the surface can be reduced or even omitted. The process parameters can vary in a wider process windows, for example resulting in a higher

blasting pressure and a reduced blasting duration. The choice of nitrides furthermore allows the use of more coarse-grained blasting material. This directly implies the possibility to achieve a higher roughness of the surface with a reduced contamination of the surface.

In accordance with the invention, having the forgoing and other objects in view, there is also provided a method for mechanical treatment of a surface of a metallic substrate of an article of manufacture comprising the step of treating the surface with abrasive particles which particles have on average a fracture toughness between 5.5MPa*$m^{0.5}$ and 10.0 MPa*$m^{0.5}$.

In accordance with another feature the particles comprise aluminium nitride (AlN), titan nitride (TiN), silicon nitride (Si_3N_4) or a mixture thereof. Preferably the particles used for the mechanical treatment essentially consist of one of the nitrides mentioned or a mixture thereof.

In accordance with a further feature the particles substantially consist of a sintered silicon nitride (SSN). Sintered silicon nitride has a fracture toughness from about 6 MPa*$m^{0.5}$ to 8.5MPa*$m^{0.5}$ in particular about 7MPa*$m^{0.5}$.

In accordance with an added feature the particles substantially consist of a hot pressed silicon nitride (HPSN). Hot pressed silicon nitride has a fractured toughness of about 6 MPa*$m^{0.5}$ to 8.5MPa*$m^{0.5}$ in particular about 6 MPa*$m^{0.5}$..

In accordance with an additional feature the particles have on average a diameter between 150 micrometers to 600 micrometers in particular over 450 micrometers. The average diameter is chosen as one of the process parameters applied according to the surface roughness to be obtained. Further process parameters are blasting pressure, the choice of material for the particles and blasting duration as well as other parameters, for example the material of the substrate and the material of the coating layer.

In accordance with yet another feature the particles are transported to the surface in a jet of a pressurised gaseous transport medium. Preferably a dry-blasting process is supplied. The pressurised gaseous transport medium is preferably pressurised air.

In accordance with yet a further feature a direct-type blasting apparatus is used, whereby the transport medium is pressurised to a pressure between 0.5 bar and 4 bar. Preferably the pressure of the gaseous transport medium, which preferably is compressed air, lies between 2.5bar and 4bar.

In accordance with yet an added feature an injector-type blasting apparatus is used, whereby the transport medium is pressurised to a pressure between 0.5bar and 7bar. In particular the pressure lies between 3bar and 6bar. By using an injector type blasting apparatus the particles after hitting the surface may be recollected, cleaned and separated from other particles and be re-introduced into the injector type blasting process.

In accordance with yet an additional feature the particles are ejected from a blasting apparatus a distance of between 10cm and 50cm away from the surface of the substrate. The distance hereby is defined as the distance between the location, in particular a nozzle of the apparatus, where the particles leave the apparatus and the location where they hit the surface.

In accordance with a concomitant feature the article of manufacture comprises a body, on which a metallic layer is placed and where the surface to be mechanically treated is the surface of the metallic layer opposite to the boundary with the substrate. It is evident that the metallic layer itself maybe bounded on the surface of the body, which surface has been mechanically treated according to the method described herein. The surface of the body maybe mechanically treated in a process using the same process parameters as for the treatment of the metallic layer, like diameter of the particles, material of the particles, distance between apparatus and surface, blasting pressure, blasting duration. The process parameters could also be different with respect to the different materials of the substrate of the metallic layer and a further layer to be placed on the metallic layer, which further layer could be a ceramic layer.

In accordance with again another feature the metallic layer substantially consists of an alloy or an intermetallic compound. Such a metallic layer may itself serve as a corrosion protective coating or an oxidation protection coating.

In accordance with again a further feature the metallic layer is a metallic anchoring layer (or also called adhesion layer), for bonding a thermal barrier layer. The thermal barrier layer preferably contains zirconia (Zro_2) which, due to its relatively high and therefor metal-like expansion coefficient, is particularly suitable for providing the adhesion-promotion layer with a thermal barrier coating. A zirconium layer is preferably partially stabilised by adding 5wt-% to 10wt-% of yttrium oxide . Other ceramic material for the thermal barrier layer are also possible which are for example metal ceramic oxides, in particular having a perofskite structure (for example Lathanaluminate), a pyrochloride structure (for example Lathanhafnate) or a spinell structure, for example $MgAl_2O_4$. The thickness of the thermal barrier coating is preferably above 500 micrometers, in particular above 200 micrometers. The thermal barrier layer could be applied by any suitable method in particular atmospheric plasma spray (APS) or physical vapour deposition (PVD).

In accordance with again an added feature the anchoring layer substantially consist of a MCrAlY alloy. This alloy is widely known in particular in the field of coating of components to be exposed to high temperatures from above 500 °C to about 1200°C, in particular components of combustion turbines, furnaces etc. In the general term MCrAlY M represents at least one of the elements from the group including iron, cobalt and nickel. Cr stands for chromium and Al for aluminium. Y (or sometimes X is used instead of Y) stands for yttrium or a metal which is selected from the group including scandium, rhenium and the rare earth elements which are equivalent to yttrium. In some cases additional elements are included so in addition to yttrium also rhenium or any other of the above mentioned elements are included. The metallic layer, in particular an adhesion layer and more particular a MCrAlY alloy layer is preferably applied to the surface of the substrate by using thermal spraying techniques, in particular atmospheric plasma spray (APS), vacuum plasma spraying (VPS), low pressure plasma spraying (LPPS) or physical vapour deposition (PVD).

In accordance with again an additional feature the article of manufacture is a component to be exposed to high temperatures, in particular above 500°C. Applying a thermal barrier coating to the article of manufacture, for example a zirconia layer the article of manufacture is protected against temperatures of about 950°C to about 1300°C.

In accordance with still another feature the article of manufacture is a component of a combustion turbine. Such a component is for example a heat shield element used in a combustion turbine, a turbine blade, a turbine vane, a shroud element attached to the wall structure of a gas turbine or any other component used in a combustion chamber. Components of a combustion turbine which are in contact with the hot exhaust gas resulting from the burning of fuel in the combustion chamber may be exposed to temperatures of about 900°C to over 1300°C. Therefor it is essential for the trouble-free operation of a combustion turbine, that coatings applied to articles of manufactures used in a combustion turbine are firmly bonded to the article of manufacture. An efficient and contamination free treatment of the surface of the article of manufacture prior to coating is essential for this, which is achieved with the method described herein.

Although the invention is illustrated and described herein as embodied in a method to prepare the surface and adjust the surface roughness of article of manufacture, in particular a component of a combustion turbine it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of the equivalents of the claims.

The method of the invention, however, together with additional objects and advantages thereof will best understood from the following description of specific embodiments when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG 1 shows a fractional cross-sectional view through a portion of a body of an article of manufacture;

FIG 2 shows a fractional cross-sectional view through a portion of a body of an article of manufacture having a metallic coating layer;

FIG 3 shows a fractional cross-sectional view through a portion of a body of an article of manufacture having a coating layer structure;

FIG 4 shows a perspective view of a turbine blade;

FIG 5 shows a perspective view of a heat shield element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the figures of the drawing, components corresponding to one another of a respectively shown exemplary embodiments in each case have the same reference numeral. The drawing is simplified in order to emphasise certain features.

Referring now to the figures of the drawings in detail and first particularly to Figure 1 thereof, there is shown in a cross-sectional view a portion of an article of manufacture 1. The article of manufacture 1 (see for example figures 4 and 5) has a body 2 consisting of a base material, which may be in particular, a nickel super alloy or a cobalt super alloy. The body 2 has a surface 7. Surface 7 is treated prior to applying a coating to the body 2 by exposing the surface 7 to a jet of abrasive particles 5. The abrasive particles 5 are carried within a pressurised transport or carrier medium 8 in particular compressed air. The jet of the transport medium 8 including the abrasive particles is generated in a blast apparatus 9. The abrasive articles 5 by bouncing against the surface 7 lead to a smoothening of the roughness of the surface 7 and also to a cleaning and activating of the surface 7. As abrasive particles 5 particles are used which consist of aluminium nitride, titanium nitride, silicon nitride or a mixture thereof. The jet of particles 5 is inclined under and angle α to the surface 7. This angle α lies between 20° and 90°, in particular is about 60°. Along the trajectory of the beam of particles 5 the blast apparatus 9 and the location where the particles 5 hit the surface 7 are spaced apart a distance D. This distance D lies preferably between 10cm and 50 cm.

Figure 2 shows a body 2, for example the body 2 as shown in figure 1, which is coated by a metallic layer 3. Now the metallic layer 3 represents the substrate 6

which has the surface 7, which is to be mechanically treated. The metallic coating layer 3 is preferably an adhesion or anchoring layer and has been applied by using a physical vapour deposition (PVD) process, in particular electron beam physical vapour deposition (EB-PVD) or by plasma spraying. The metallic coating layer 3- in particular in case of an article of manufacture 1, which is the component of a combustion turbine - consists of an alloy widely known as MCrAlY or an aluminite for a corrosion protective coating.

The surface 7 of the metallic coating layer 3 is prepared and treated before bonding a further layer, in particular a ceramic thermal barrier layer4, to the surface 7. The surface 7 is grit-blasted with abrasive particles 5, which may consist of the same materials as discussed relating to figure 1, in particular a metallic nitride or silicon nitride. Particles 5 may also have the same diameter on average, in particular between 150 and 600 microns, in particular between 450 and 600 microns and the client angle α of inclination also lies between 20 and 60°. The angle α, the material of the abrasive particles 5, the distance D between blast apparatus 9 and the location on the surface 7 at which the particles 5 hit the surface 7 as well as the duration during which particles hit the same location of the surface 7 as process parameters depend on the roughness of the surface 7 which has to be reached by the mechanical treatment. The pressure to which the carrier medium 8 is pressurised also depends on the choice of material for the abrasive particles 5, the material of the coating layer 3 and the roughness to be reached.

The blast apparatus 9 shown in figure 2 may be the same one as shown in figure 1.

In figure 3 a fractional cross-section view of the particle of manufacture 1 is shown, which is obtained after applying a thermal barrier layer 4 to the body 2 after the mechanical treatment of a metallic bond layer 3. Between the metallic bond layer 3 and the ceramic thermal barrier layer 4 an oxide layer 12 is formed. The ceramic thermal barrier layer 4 is - in particular for a component of a combustion turbine - made of a metal oxide or a mixture of different metal oxides, for example partially stabilised zirconia. Depending on the choice for the alloy for the metallic coating layer 3 the oxide layer 12 includes aluminium or chromium oxide and is formed due

to thermal oxidation (thermally grown oxide, TGO). The oxide layer 12 may also be created during an intermediate process step through oxidation of the metallic bond layer 3.

Figure 4 shows a perspective view of an article of manufacture 1, which is a turbine blade of a combustion turbine. Blade 1 has an active blade area 10, which is coated with a thermal barrier coating 4. During the normal use of the combustion turbine the active blade area 10 of the turbine blade 1 is exposed to a stream of hot exhaust gas 13, which is generated by burning fuel in a not shown combustion chamber. Turbine blade 1 further comprises a fastening region 14 which is a blade root section having a fir-tree fastening profile. Opposite to the blade root 14 the active blade region 10 is bounded by a shroud 15, which serves to seal the stream of hot gas 13 off from other areas of a combustion turbine. The thermal barrier layer 4 is bonded to the active blade region 10 after having treated the surface 7 of this active blade region 10 with the method as described above.

In figure 5 in a perspective view an article of manufacture 1 is shown, which is a heat shield element of a not shown combustion chamber of a combustion turbine. The heat shield element 1 has a through hole 16 for a not shown fastening element. For example a bolt guided through the through hole 16 is put into connection with a not shown wall structure for securing the heat shield element in a combustion chamber. The surface of the heat shield element 1 is prior to coating with a thermal barrier layer 4 mechanically treated with the method described above. Due to this the thermal barrier layer 4 shows an improved bonding capability for withstanding high temperatures and for resisting against a hot aggressive gas flowing along the thermal barrier layer 4.

The invention is distinguished by a method of mechanical treating the surface of an article of manufacture with abrasive particles comprising metallic and/or silicon nitrides which leads to a very low contamination of the surface with the material of the particles, a cleaning and activating on the surface as well as an accurate adjustment of a predetermined surface roughness of the article of manufacture. A surface, in particular metallic surface, mechanically treated in such a way leads to an improved bond between a metallic surface and a metallic coating as well as between a

metallic surface and a ceramic coating, in particular a ceramic thermal barrier coating.

Claims

1. Method for a mechanical treatment of a surface (7) of a metallic substrate (6) of an article of manufacture (1) comprising the step of treating the surface (7) with abrasive particles (5), which particles (5) comprise a metallic nitride and/or silicon nitride.

2. Method for a mechanical treatment of a surface (7) of a metallic substrate (6) of an article of manufacture (1) comprising the step of treating the surface (7) with abrasive particles (5), which particles (5) have on average a fracture toughness of between 5.5 $MPa*m^{1/2}$ and 10.0 $MPa*m^{1/2}$.

3. Method according to claim 1 or 2 wherein said particles (5) comprise aluminium nitride (AlN), titan nitride (TiN), silicon nitride (Si_3N_4) or a mixture thereof.

4. Method according to any of the preceding claims, wherein said particles (5) substantially consist of a sintered silicon nitride (SSN).

5. Method according to any of the claims 1 to 3 wherein said particles (5) substantially consist of a hot pressed silicon nitride (HPSN).

6. Method according to any of the preceding claims, wherein said particles (5) have on average a diameter between 150 micrometer to 600 micrometer, in particular over 450 micrometer.

7. Method according to any of the preceding claims wherein said particles (5) are transported to said surface (7) in a jet of a pressurised gaseous transport medium.

8. Method according to claim 7, wherein by using a direct-type blasting apparatus (9) the transport medium is pressurised to a pressure between 0,5 bar and 4 bar, in particular between 2.5 bar and 4 bar.

9. Method according to claim 7, wherein by using an injector-type blasting apparatus (9) the transport medium is pressurised to a pressure between 0,5 bar and 7 bar, in particular between 3 bar and 6 bar.

10. Method according to any of the preceding claims wherein said surface (7) is grit blasted with said particles (5).

11. Method according to any of the preceding claims wherein said particles (5) are ejected from a blasting apparatus (9) a distance (D) between 10 cm and 50 cm away from said surface (7).

12. Method according to any of the preceding claims, wherein said article of manufacture (1) comprises a body (2) on which body (2) a metallic layer (3) is placed and said metallic layer (3) comprises said surface (7).

13. Method according to claim 12, wherein said metallic layer (3) substantially consists of an alloy or an intermetallic compound.

14. Method according to claim 12 or 13, wherein said metallic layer (3) is a metallic anchoring layer for bonding a thermal barrier layer (4).

15. Method according to claim 14 wherein the anchoring layer (3) substantially consists of a MCrAlY alloy.

16. Method according to any of the preceding claims wherein said article of manufacture (1) is a component to be exposed to a high temperature, in particular above 500 °C.

17. Method according to claim 16, wherein said article of manufacture (1) is a component of a combustion turbine, like a heat shield element, a turbine blade, a turbine vane, a shroud element, a component of a combustion chamber.

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Application No:	GB 0112873.5	**Examiner:**	Matthew Lawson
Claims searched:	1 and 3-17 in part	**Date of search:**	17 December 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): B3D (DBM); C4V

Int Cl (Ed.7): B24C 11/00

Other: Online: PAJ, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	EP 1016735 A	(SIEMENS) - WPI Abstract Accession No. 00-425189/37	1-17
A	EP 0492323 A2	(MTU) - WPI Abstract Accession No. 92-218568/48.	12-17
X	JP 070308859 A	(TOSHIBA) - WPI Abstract Accession No. 96-044552/05 and the PAJ abstract.	1,3,6-17
X	JP 060312373 A	(KYOCERA) - PAJ abstract.	1,3-17
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X	US 5238467	(HASHIBA) - column 1 lines 7-11 and column 3 lines 22-23 & 29-32.	1,3-13
X	US 5024711	(GASSER) - the whole specification.	1,3-13
Y	US 4761346	(NAIK) - the whole specification, especially column 1 lines 13-16 and column 2 lines 53-68.	1-17

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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